

EFFECT OF POZZOLANA ON THE ENVIRONMENTAL INFLUENCE OF CEMENT INDUSTRY

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ABSTRACT

Because of needing to usual usage of cement in the civil and industrial works, different resolutions which can decrease amount of environmental destruction with this Industry, must be examined. One of resolutions is using of the pozzolana cements. The pozzolana are silica and silicon alumina materials which cause improvement of cement properties with adding it to cement, in this article with doing of different trials on the Portland and pozzolana cement of western Azerbaijan in Iran their properties (amount of consumed energy and strength) has examined. These trials was carried out from 2006 and continued until 2008. Continuity of research is concentrated on the amount of diffusion harmful gases such as, in both sort of cements as researches show with using pozzolana diffusion of C_{O_2} is decreased within 3.5 - 7% and this event cause decrease of cement environment destructive influences.

KEYWORDS: Cement, Environmental, Pozzolana, CO₂

INTRODUCTION

Environment protection in any branch of industry is a fundamental part. Production of cement and using is in the concrete, produce a lot of harmful gases such as CO₂, therefore the new techniques in production of cement must be used for decreasing of its influences on the environment.

Pozzolana cement, which is produced by adding amount of pozzolana instead in lime of clinker have decreased much harms of production of cement.

In this article improvement of cement was caused by doing of different trials on the Rashakan pozzolan cement strength and comparison it with Portland cement and drawing their diagrams, then amount of decrease of consumed energy that is prepared of fossil and organic fuels was calculated by doing some trials on the Band index of pozzolana cement and determining it and so its environmental influences.

3 critical reasons for using pozzolana in cement industry:

- Decrease of greenhouse gas diffusion such as CO₂
- Concrete stability increase with increasing its age
- Decrease of consumed energy in attention pozzolan band index.

Production of pozzolana cement, decreases amount of product gases in Portland cement, about 5-7% amount of produced CO_2 in cement industry and is 5-10 percent of total produced CO_2 in university; this percent can be decreased to 4-9% with using of pozzolana cement.

In attention to, produced CO_2 , cause increasing of earth thermal in addition to its direct influences, therefore it damage to environment with two different ways.

In this article both Portland and pozzolana cements are examined and at the end, environmental influences of pozzolana cement are described.

WHAT'S THE POZZOLANA?

Pozzolana is nature or synthetic material with active silica or alumina silica that not have binding behavior alone, but in powder shape and with water existence in ordinary temperature can have chemical reaction with calcium hydroxide and create binding composing. Pozzolana material can achieve from uncrystallized volcanic ash, nature pozzolana, rock powder, clay rocks, opalin cherts, diatomaceous alkalized soil, windy ash, siliceous fly ash and etc.

With applying of pozzolana in cement industrial in additional economization in fuel and energy consumption can reduce greenhouse gas emission such as (CO_2) and environmental destructive impact of Portland cement product.[1]

PORTLAND CEMENT

In building industries cement is material that is used for binding different materials together such as sand, brick, gravel, rock, ...and

The main compounds of this cement are lime materials.

Due to, great part of needed raw materials for cement is composed of calcium carbonate, therefore heating to raw materials in cement furnace with decrease of weight about 35% is caused by diffusion of CO_2 . Therefore, for producing of any tone cement, 5.1 tones of raw materials is used.[2]

Needed raw materials in cement industry including the following limestone, clay, quartzite, gypsum, ..., The feed of cement furnace usually contains of 78-80% of calcium carbonate which this material in production of cement produce environmental destructive gases such as CO_2 , CO , SO_2 , NO_x ,...

This much diffusions of this gases particularly CO_2 lead to Earth warming in this article environmental influences related to production of cement are surveyed so are amount of decrease of this destructive influences with using of suitable replacements such as pozzolana.

- **Cement Production Process**

Heating to lime with amount of other materials such as clay until 1450 which needs much fuels, product the material called clinker that is cement major element of clinker is composed of lime, iron, gravel which is produced in high temperature and it is including the following : silica, calcium oxide and amount of oxide iron and...

Wearing clinker with amount of gypsum, produce ordinary Portland cement powder with consider to mixing this material with addition materials such as pozzolana, limestone, furnace slags, clum, mixture cements with different properties is produced that this properties depend to sort of addition materials.

Mixture and ordinary Portland are most traditional cements in IRAN.[2] Simple form of production of cement process:

Limestone → crusher → raw meal → kiln → clinker + additive → grinder = cement

Figure 1 shows direction of production of cement with any action environmental impacts. Diffusions of this process to environment including the following:

CO, CO₂, particles, nitrogen oxides and less amount SO₂.

2-3 amount of emission co₂ with using the Portland cement:

In the cement co₂ liberation in 2 states:

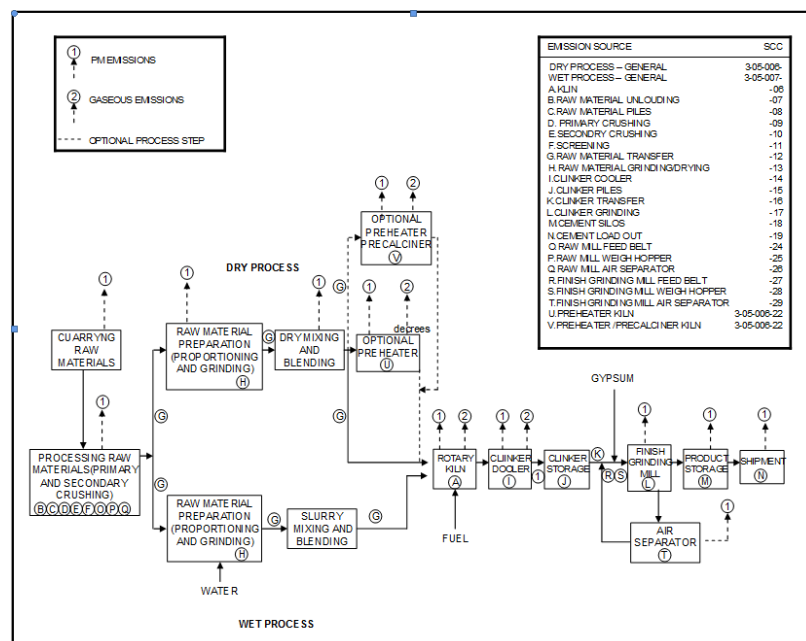


Figure 1: Direction of Production of Cement with Any Action Environmental Impacts

First stage due to baking material on furnace (figure) this is, either co₂ realize from furnace fuel and material reaction on furnace:

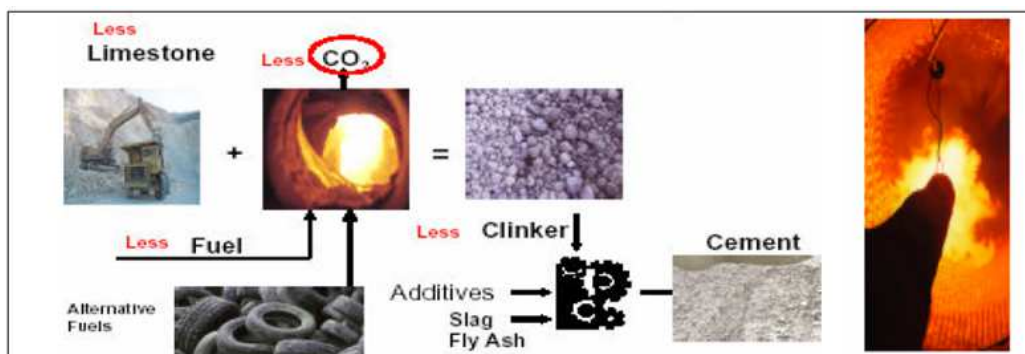
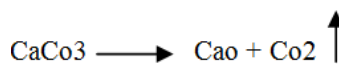


Figure 2: Combustion in the Furnace is Major Place for Co₂ Production in Cement Plant [3]

Second stage of realize CO_2 due to chemical reaction provide matrix. Because of over, influence CO_2 on destruction environmental of all affect this industry, on the following describe production of that in global:

Cement industry produce 5 -10 % of all rate CO_2 that result from anthropogenic in global productions. This is 50% of amount chemical reaction that lime turn into clinker. 40% due to furnace and 10% due to transmitter and electric current activity. Therefore this industry decisive to reduce this rate of CO_2 and decrees environmental problems.

Three major technique exist for reduction of CO_2 that production in one ton of cement.

- Economization, optimization, increase efficiency and ultimate recovery and equipment capacity for wise use of combustion (fuel) sand material in this industry.
- Decreases rate of clincher from replacement other mirror production that needs little thermal process or change on mixer cement production increase using of blend cement.
- Using of un convention fuels with little carbon such as waste material, losses fuels, biochemical fuels named to Cree fuels, subject to situation for convenient fuels in cement industry.

on the following paper describe the roll of pozzolana on reduction impact destructive environmental of the cement industry.

POZZOLANA CEMENT

Pozzolana cement is composing of 5% to 40% nature pozzolana (with certain fragmentation) which in abundant with water in form of blinding material, applied in building works. Preliminary for this reason that seawater and water having sulphate (in gypsum soil), not having bad impact on concrete, the pozzolana add to cement.

In building and resident investigation center of Iran, has been done investigation in this field and obtain good results that indicate high efficiency of cement.[3]

POZZOLAN IN IRAN

Pozzolan in Iran discovered in 1320. natural pozzolan sources in Iran including the following : Gajrood, Lumar, Rashskan, Ahar, Shahin dezh, Bostan Abad,...

Sahand, Damavand, Taftan mountains and Kerman province are rhe places with natural pozzolan sources in Iran too. Now more than 60 lines exist in Iran and yearly more than 30 million tones are produced. It is programmed that at the end of fourth program of development, production of cement increase to 70 million tones for any year and for production of this amount if cement much electrical energy and thermal are needed 4-6 GJ/t.[5]

It is important that the value of consumed fuel of cement plans in Iran is estimated about 250 m\$, this digit is equal to 1750 ml furnace oil and about 500 Mm³ natural gas this amount of consumed fuel product 5-10% of total deducted CO_2 of Iran industries. Table 1 shows chemical specifications of pozzolana cement in Abyek company is compared with nation standards of Iran and ASTM

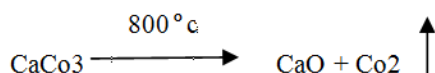
Table 2 shows physical specifications of pozzolan cement in Abyek company is compared with nation standards of Iran and ASTM.

The comparison shows strength and stability of pozzolan cement

A RESEARCH ON THE ENVIRONMENTAL INFLUENCE OF PORTLAND CEMENT AGAINST POZZOLANA CEMENT

Impact Destructive Environmental Portland Cement

Cement industrial because of product CO_2 have great share in environmental pollution about 5%-10% in all around the world that 45% of it caused by energy consumption and 55% of it caused by fallow process:



Per one ton production of cement, has 0.7-1 ton CO_2 emission. Environmental problems are one of the problems about cement industrial especially in development countries. [2] To create one ton of cement, approximately 6300000 kJ of energy is needed (6 millions BTU), this energy consumption in countries that used fossil fuel, in additional environmental disturbance, decrease greenhouse gases action of plants.

Table 1: Chemical Comparison of Pozzolana Ordinary Cement (Abyek Cement Company) with Iran Nation and ISTM Standard

Properties of Abyek Pozzolana Cement	Quantity in America Standard (ASTM c565-89)	Quantity in Iran Standard (3432)	Parameters
2.61	max 5	max 5	MgO(%)
2.1	max 4	max 4	So ₃ (%)
1.3	max 5	max 5	Thermal lessening(%)
less than 0.1	-----	0.1	CL ion(%)

Table 2: Physical Comparison of Pozzolana Ordinary Cement (Abyek Cement Company) with Iran Nation and ISTM Standard

Properties of Abyek Pozzolana Cement	Quantity in Iran Standard (3432)	Quantity in America Standard (ASTM c565-89)	Parameters
3250		3000	special area(cm ² /gr)
0.14	max 0.8	max 0.8	Autoclave expansion(%)
169	min 45	min 60	initial setting power(minute)
230	max 420	max 420	ultimate setting power(minute)
211	min 125	min 100	three days compress strength(kg/cm ²)
311	min 193	min 175	seven days compress strength(kg/cm ²)
405	min 300	min 300	twenty eight days compress strength(kg/cm ²)
less than 70	max 70	max 70	hydratation heat in seven days(cal/gr)
less than 80	max 80	max 80	hydratation heat in twenty eight days(cal/gr)
10_15		5_15	quantity of pozzolana(%)

Whereas cement utilization is necessary nowadays, therefore with applying constructive approaches that reduces unfavorable environmental impact of cement production by utilization of pozzolana in cement.

Decrease of Environmental Destructive Influence of Portland Ordinary Cement with Using of Pozzolana

In this paper attempted that with study working that had been done in research and inhabit company s Iran, And doing various test on different cement (pozzolana, Portland) of Rrashakan mines productions. At the end compared both of

cement relate to stability and competent and bond index and describe benefits pozzolana cement rather than Portland cement.

Determining Band Index Test

This part studies pozzollan influence in amount of consumed energy foe cement according studies on Rashakan cement plan, using of pozzolan decrease consumed energy of plan.

In the first, pozzolan is entered to jaw crusher then it is sieve analyze and the material with +16 mesh size is separated and then F is calculated, then determining Bond Index process with a method of Tehran university is done (table 5).

10 stages of grinding on the pozzolan have done and in any stage Gi related with that stage if calculated

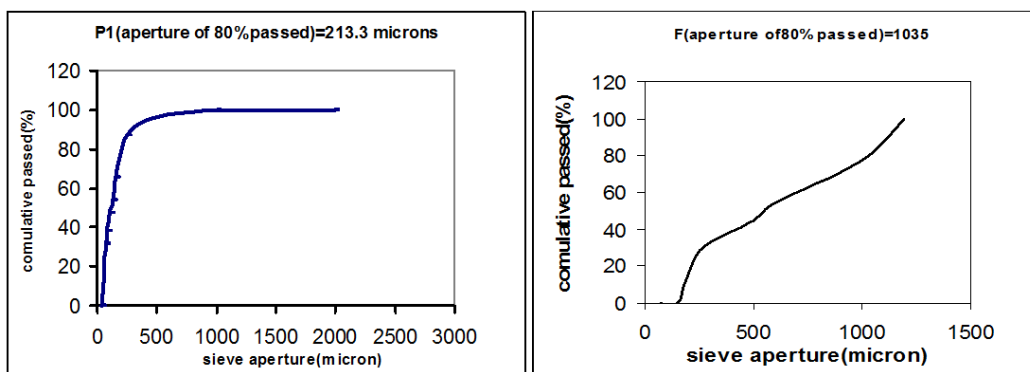


Figure 3: Sieve Analyze of -1190µ Products of Jaw Crusher

At the end of milling process production of sliming for 4 last stage send to sieve analyze to determine amount (p). notice that screen was using in milling process has p1=200 mesh (149 microns) aperture when this elements determined. Bond index pozzolana equation is as follows:

$$Wi = \frac{11.76}{(P_1)^{0.23} \times (Gi)^{0.75}} \left(\frac{10}{\sqrt{P}} - \frac{10}{\sqrt{F}} \right)^{-1}$$

$$Wi = 10/88 \frac{kwh}{s.t} = 11/99 kwh/t$$

$$Wi = \frac{11/76}{(149)^{0.23} \times (.887)^{0.75}} \times \left(\frac{10}{\sqrt{213/3}} - \frac{10}{\sqrt{1035}} \right)^{-1} = 10/88$$

That:

I: Aperture that 80% feed to mill passed from it.

P: Aperture that 80% production from 3 last stage passed from it.

Pi: Selective aperture for various stage

Ci: Average of weight materials passed from ... screen per 1 round mill in all stage

Accuracy of this process compared with other tests. That indicating good result.

For determine bond index lime, similar to process has been done, it index. for lime achieve 13.4. with compared for both pozzolana and limestone result that amount of consuming energy for crushing pozzolana less than limestone.

Therefore replacement pozzolana instead of limestone addition to reduction consumption energy and produce inexpensive need to environmental problems.

Determining Strength of Pozzolana Cement Tests

To study the impact of the application of pozzolana in ordinary cement, the experiment has been done on Ahar pozzolana mine that supply applied pozzolana in Urmia RASHAKAN cement plant in this experimentation 3, 7, 28 day strength of concrete with different applied pozzolana in clinker, compared with concrete that composed of clinker of this plant (without pozzolana) properties of Ahar pozzolana mine presented in figure 4.

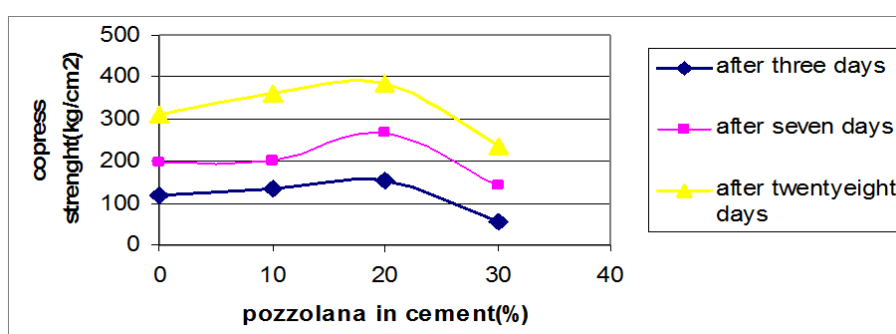


Figure 4: Impact of Ahar Mine Pozzolana in Compress Strength of Concrete Samples

Concrete samples, BC0, BC1, BC2, BC3 respectively composed of 0,10,20,30 percent pozzolana in pozzolana cement that construct these concrete samples. In Additional of pozzolana, to increase the interception time of cement, about 3% of gyps added to clinker of cement then concrete provide in 10*10*10 cm³ cast with water-cement ration, 0.5 and with cement-sand gravel ration, 0.33. then after 24 hours take out from castes and placed in water with room temperature (25°C). Notice that gravel and sandstone used in concrete properly washed. Result of different strength of samples presented in Table 3 as observed from figure 1 with increase of cement pozzolana until 20%, different strengths of concrete samples increased and after 20% strengths of samples considerably decreased. With attention that special pozzolana cement composed about 40% pozzolana and still observed increase in cement strength but in these experimentations with adding about 30% pozzolana, considerably observed reduction in strength. Therefore can result that pozzolana impact in strength depended upon kind of pozzolana, fragmentation and operation condition.

Table 3: Result of Different Strength of Samples Presented in

Samples with Different Concrete	Three Days (kg/cm ³) Strength	Seven Days (kg/cm ³) Strength	Twenty Eight Days (kg/cm ³) Strength
Concrete from plant clinker (BC0)	116.6	195.1	311.2
Concrete with 10% pozzolana cement	135.4	201.1	362.1
Concrete with 20% pozzolana (BC2) cement	153.1	269.6	387.6
Concrete with 30% pozzolana (BC3) cement	55.6	143.3	237.7

But by increase of utilization of this cement, the strength of the pozzolana cement can be high from ordinary cement.

The advantage of pozzolana cement presented in follow:

- Strengthen against of chemical material and sewage
- Higher ultimate strength
- Best penetration ability and workability for vibration
- Maintenance of building material and armature inter of cement against corrosive material.
- Pull out alkaline material from concrete
- Lower expansion and applicable in great shotcrete
- Lower hydration heat in great shotcrete
- Pozzolana concrete due to best permeability and lubricate properties, hasn't crack.
- Maintenance of natural reserve because of reduce in energy consumption and material that applied in cement
- Decrease in weather pollution due to replacement instead clinker and reduction in fossil fuel consumption
- Decrease in equipment corrosion in mills
- Decrease in electrical energy consumption for grinding in cement
- Decrease in price of cement.

Determining Amount of Emission CO_2

Amount of CO_2 production in one ton production of Portland cement is 0.7-1.0 ton that share of lime changing process to clinker in cement industry is 50% therefore amount of CO_2 that product by lime changing is:

$$(0.7-1.0) \times 50\% = (0.35-0.5) \text{ ton},$$

If 20% of that lime replaced by pozzolana, the amount of production CO_2 in this cement (by lime changing to clinker) is:

$$(0.35-0.5) \times 0.8 = (0.28-0.4) \text{ ton},$$

Amount of ordinary cement production in all countries is about 2611×10^6 tones and with add 20% pozzolana instead of lime in this cement industry, amount of CO_2 production lime changing to clinker is:

$$0.8 \times 2611 \times 10^6 \times (0.35-0.5) = (731.08-1044.4) \times 10^6 \text{ ton},$$

CONCLUSIONS

- Using of pozzolana in reaction of producing cement in clinker decreases damaging of emission CO_2 .
- Per ton cement products about 0.7-1 ton CO_2 . that share of limestone in this process is 50% therefore by utilization about 20% pozzolana in cement this range reach to 0.63-0.9 ton CO_2 and with attention to share of CO_2 that produce

by lime heating in plant cements in all of the world(5%-10%),share of cement plant in co2 emission would be 4%-8%.

- Decrease in electrical energy consumption and thermal energy obtain from fossil fuel, therefore decrease in environmental pollution.
- Increase the fortification of construction and decrease the corrosion against the acid rain that has large helping to environment.

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